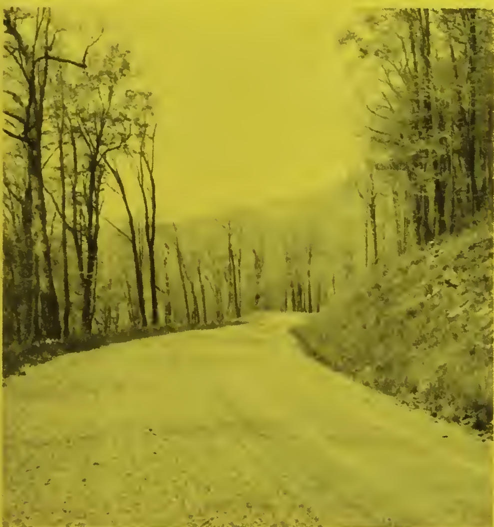
PERMANENT LOGGING ROADS FOR BETTER WOODLOT MANAGEMENT



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PREFACE

Availability of professional guidance in forest management coupled with a continuing demand for forest products makes intensive management feasible for timberland owners. Ready access to all parts of a timber producing area is a prerequisite for intensive management, adequate protection, and successful harvest operations. Roads and trails, well located and constructed to sufficiently high standards, provide the necessary access just as do streets and walks in the city.

The principle of access applies to small properties as well as large. Providing access for the farm woodlot does not usually involve difficult engineering problems, but, even so, the location and design of roads and trails warrants careful consideration. Roads may serve a variety of useful purposes. Good location and design facilitates operations; poor location and design may handicap operations and may even induce undesirable effects, such as soil erosion and siltation.

Drainage is probably the most important factor to be considered in locating and constructing logging roads. The first priority for a good road bed is to keep the soil as free of water as possible.

Erosion on logging roads is a serious stream pollution problem. Generally speaking, the most significant place in our forests where erosion occurs is on the roads. Vegetative cover and litter from the forest floor is removed during the road construction process. Rain and surface water then run over the exposed areas, building up energy as slopes and distances increase. Soil particles are torn apart and washed into the streams, resulting in muddy water and siltation. Small amounts of mud in water make it unsuitable for human consumption and most industries cannot use muddy water. Water with a turbidity of over 5 parts per million is considered unfit for domestic use, and 25 ppm is undesirable for most manufacturing processes. Damage to rainbow trout starts at about 90 ppm, and 400 ppm is approximately the threshold level for damage to other fish.

Air and stream pollution are probably two of the most popular environmental issues in our country today. These problems and effects are discussed in our homes, in the streets, in our schools, in the news media, and in our State and Federal legislative bodies. To illustrate how important the ecological concern is, it is estimated that 3,000 bills (or 20 percent) of all those introduced by Congress in 1971 were concerned with environmental issues.

This guide is directed to the need for proper construction and maintenance of a transportation system on a typical woodlot. It applies to situations most commonly encountered in the Northeast and provides the principles for a generally applicable type of low-cost, low-speed road. Good judgment must be used in applying these principles because of the wide variety of topography, soils, climate, and other factors which prevail in different parts of the Northeast.

A caution: laws and regulations now cover some subjects discussed in this book. We believe the tables, formulas, and other guidelines are the best available for general use and without more detailed facts; however, applicable laws and regulations should be followed, and more specific information and detailed calculations are encouraged. See Appendix Figures 32 and 33.

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LOCATING THE ROAD

Basic considerations

Topography will often dictate the approximate location and extent of a road system necessary to bring timber out of the woods. In other cases, property lines, economic limits on skidding, and other features may determine to what point a truck road shall be extended into the timber. Generally, the haul road should be planned to the farthest point consistent with good economics and sound operating principles.

Good appearance and safety are increasingly important in logging roads. Locating a curve near the main road will eliminate undesirable long tunnel views. The logging road ideally intersects the main road at right angles and at a point giving good visibility in both directions.

Items to consider in planning and locating a logging road are:

1. *Grade.* The slope of a road is called grade. Generally, this incline is expressed in percent. A 10 percent grade is one that goes up or down 10 feet for every 100 feet of length.

Logging roads in mountain country are usually too steep. Excessive grades increase maintenance and trucking costs and frequently make it too expensive to keep roads intact. Grades should be kept below 10 percent except for short distances where this limit may be exceeded to a maximum of 15 to 20 percent.

Long, steady grades permit the build-up of drainage water and increase the erosion potential unless adequate drainage structures are installed. To facilitate natural drainage, occasional breaks to level or adverse grade may be planned. Likewise, it is well to avoid long, level sections of road because such sections are difficult to drain properly. Grades of 3 to 5 percent are desirable.

2. *Slopes.* Side-hill locations permit good cross-drainage. They also provide the construction advantage of balanced cross-sections which involve a minimum of earthmoving. Where slopes exceed 60 to 70 percent in grade, the advantage is lost because the road bed must be placed in solid material, with all of the excavated earth going over the side as waste. See Appendix Figures 34 and 35.

3. *Obstacles.* Rock outcrops, ledges, highly erosive soils, swampy places, and other features which are apt to present difficulties in construction should be avoided. The exact location of such obstacles must be known because they constitute control points that will influence the final location of the road. Occasionally, however, the problems are not encountered until the preliminary location is made.

4. *Distance from streams.* Stream beds do not make good roads and should not be used for that purpose. Road surface drainage should be kept out of streams by locating the road far enough from a stream to provide sufficient filtering area. See Table 1.

Table 1
Recommended Widths for Filter Strips between Logging Roads and Streams

Slope of Land between Road and Stream	Width of Filtration Strip*
Percent	*Feet*
0	25
10	45
20	65
30	85
40	105
50	125
60	145
70	165

* Double these distances for roads in municipal watersheds.

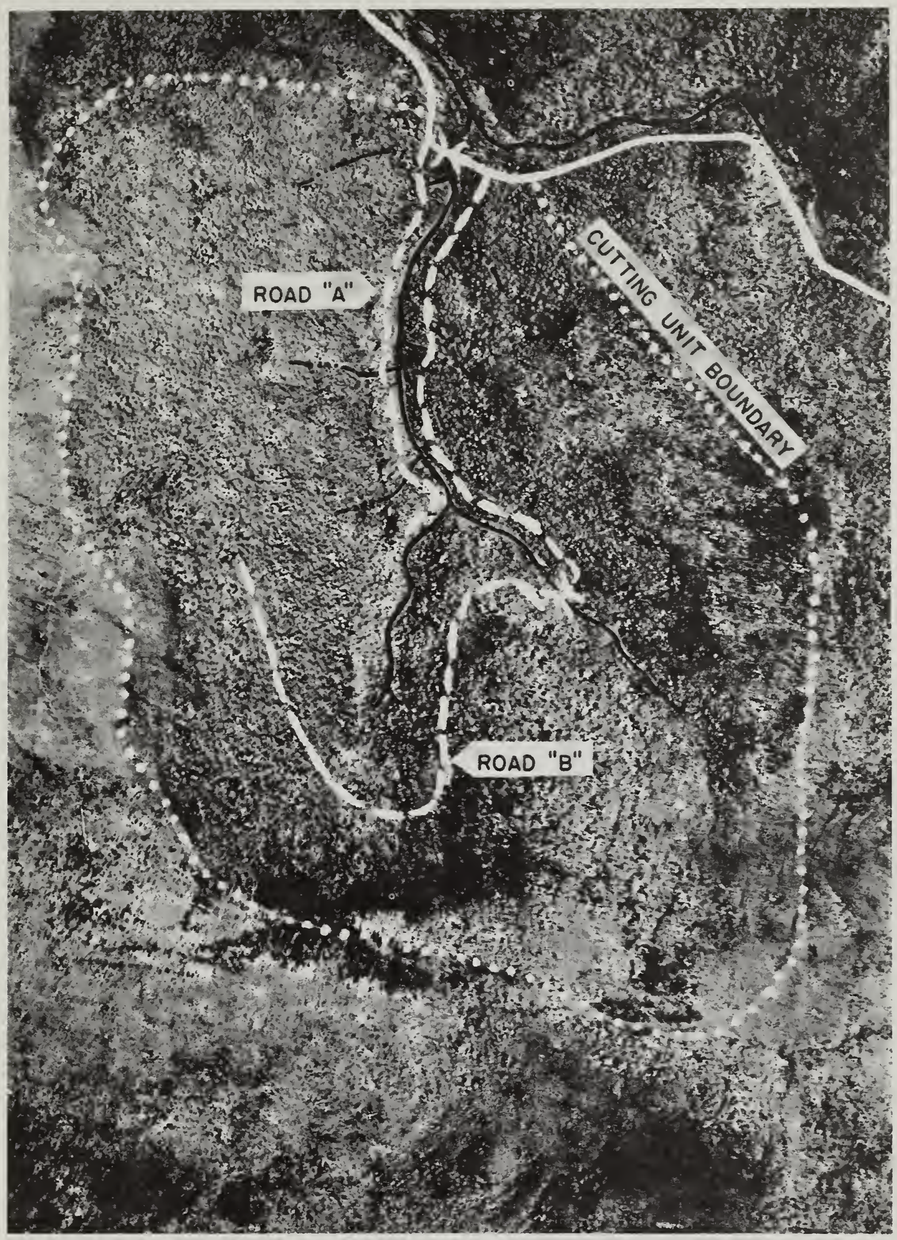
5. *Stream crossings.* Permits are required for stream crossings in some states. Stream crossings should be made at right angles wherever possible, regardless of whether the crossing is by ford, culvert, or bridge. Where water values are high, as in the case of domestic use, live water courses should always be bridged. If a stream is forded, sufficient adverse grade should be provided on the lower approach section to confine the stream to its channel even during periods of high water.

Trucks, skidders, and other logging equipment carry pollutants more dangerous than eroded soil. When fording streams, gasoline, oil, and grease are often washed from the wheels and undercarriages of vehicles. As little as 2 ppm of gasoline causes objectionable odor in domestic water supplies and the threshold for rainbow trout is about 40 ppm.

Preplanning

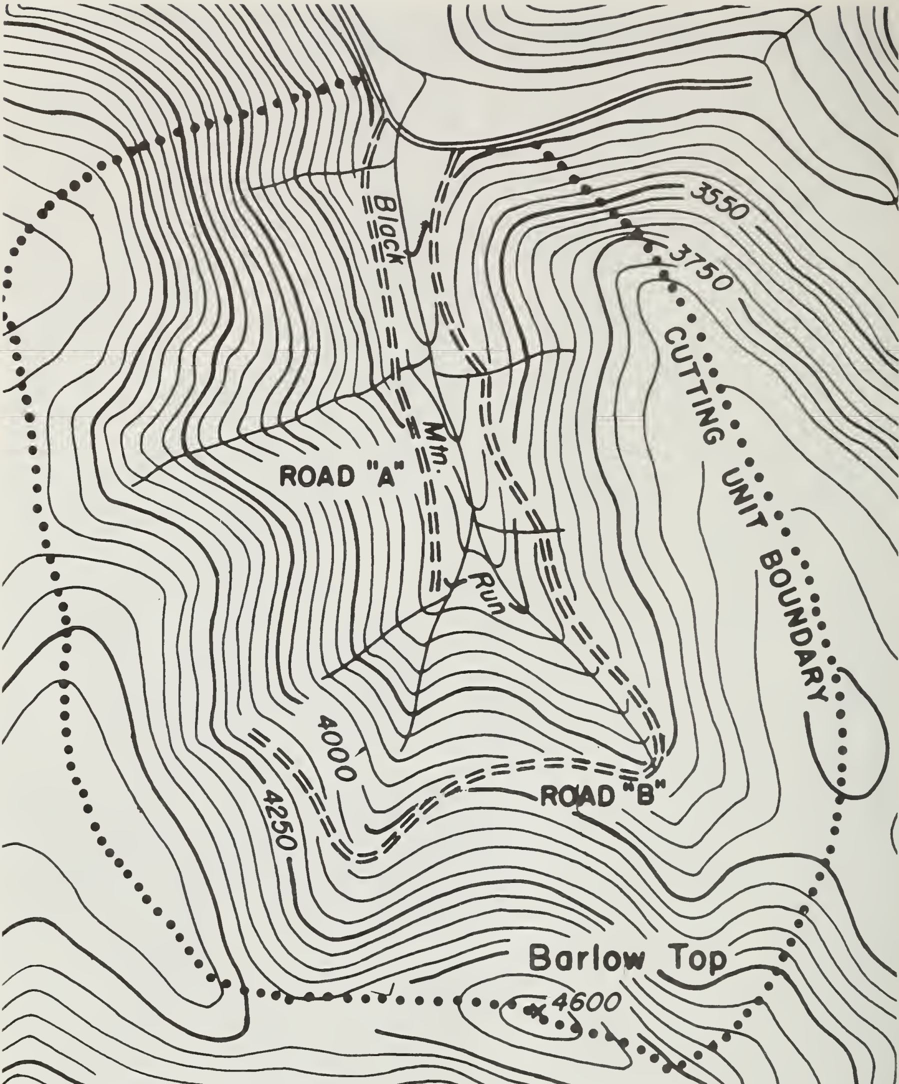
It is assumed that the road locater has some knowledge of the area to be served by the road and of the terrain and the approximate location on which the road is to be built. Proposed roads may be tentatively located on aerial photographs or topographic maps, as illustrated by Figures 1 and 2. The distribution and volume of the timber which is to feed into the road should also have been determined. See Appendix Figure 36.

The proposed road should become a permanent improvement to serve either as a continuously passable road or to be used at periodic intervals. It should be planned to assure adequate coverage of the whole area even though the area might contain blocks of timber not now operable. This coverage can be planned most effectively by plotting or sketching the road on an aerial photo or on a map.



Area of operating unit	1,020 Acres
Volume of timber to be cut	3,600,000 Board Feet
Average cut per acre	3,500 Board Feet

Figure 1. Aerial photo of logging unit showing location of permanent roads.



SURVEY DATA ON	ROAD A	ROAD B
Elevation at beginning	3,240 ft.	3,240 ft.
Elevation at upper end	3,510 ft.	4,150 ft.
Rise in elevation	270 ft.	910 ft.
Length of road	3,700 ft.	10,510 ft.
Average gradient	7.3%	8.7%

Figure 2. Topographic map of same logging unit shown in Figure 1. Lack of detail on topographic map permits only approximate location of road, but contour lines facilitate determination of road gradients. The difference in elevation and distance between two points can be determined. Dividing the difference in elevation by length of road will give sustained grade of proposed road between points.

Method of locating road

The next step in the location process is to walk the entire length of the proposed road to become familiar with the topography and ground conditions. All control points should be established at this time with only a minimum of marking necessary to indicate the route traveled.

Then follows the preliminary location survey, which can best be done by a two-man crew. Working in a downhill direction affords a better view of the terrain. The procedure usually followed is for the instrument man, with Abney Level and from the starting point, to line in the headman or flagman at a visible point in the direction of the survey. The grade is then checked with the instrument. If the grade between these points is excessive, the flagman moves uphill or downhill until the desired grade is obtained. The two points are then tied in with markers, and the same process is repeated from the advanced station. Marking can be done with axe blazes, paint, strips of cloth, or weatherproof marking tape fastened to trees. The entire course should be marked as the survey progresses, with the marked line representing the center line of the proposed road.

If, in following a predetermined fixed grade, the locater misses the desired end location point, he should work back from that end and connect the two surveys at the most convenient point. It may, however, be necessary to repeat this grade survey.

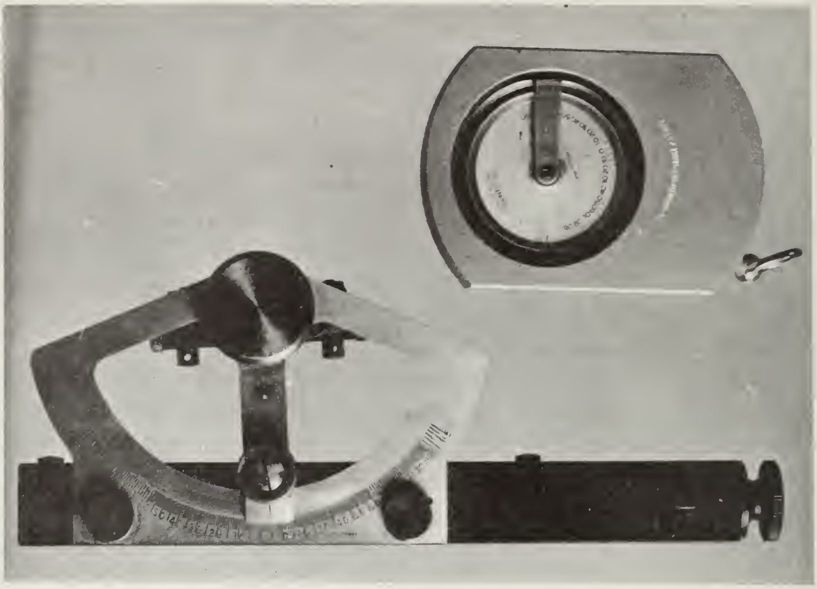
A road locater working alone can establish and maintain a desired grade by tying a flag or leaving a readily visible mark at eye-level height at the starting point of the survey. Then, taking a backsight with the instrument from the next point in the survey, the locater again clearly marks this point before proceeding. This method is repeated for every backsight between visible points along the course.

Curves and switchbacks must be of sufficient radius for trucks to negotiate easily. The radius should be no less than 35 feet for short-bodied vehicles and 50 feet for tractor-trailers. Ideally, curves and switchbacks should be planned on as level a grade as possible. Turnouts should be provided to permit the passing and parking of vehicles and should be intervisible. Advantage should be taken of topography which provides natural passing places which require little movement of materials. Necessary curves and turnouts should be staked during the location survey. See Appendix Figures 37 and 38.

Equipment needed

A hand instrument for grade estimating is essential. The Suunto clinometer is compact and available to most foresters. The Abney hand level is very convenient and easy to read. Both are inexpensive. See Figure 3. Other equipment needed for use in the field is a measuring tape, flagging material, axe or brush hook, and hand compass if bearings are desired. Aerial photos or a map of the area should be carried for reference.

Figure 3. Abney hand level and Suunto clinometer.



The use of grade and slope stakes

Should circumstances dictate that a more highly engineered road be built than is possible from a center line location survey, it may become necessary to set grade and slope stakes. In that event, grade stakes must be placed along the location survey line at 50-foot or 100-foot intervals, depending upon the uniformity of the topography. At sharp curves, stakes may be set as closely as 25-foot intervals, to assure uniform curvature. On tangents, the grade stakes should be placed in a reasonably straight line.

A grade stake marks that point on the ground and represents that point in the cross-section of the road where the "cut" and "fill" sections meet and are reduced to zero. Slope stakes mark those points in the cross-section which represent the outer limits of construction, namely, the top of the cut bank and the toe of the fill bank. However, slope stakes are normally set only on the cut side for the type of road considered here. See Appendix Figure 39.

The setting of slope stakes follows the "grade" survey as a separate operation. These stakes are placed on the uphill side of every grade stake. The principal steps in setting slope stakes are as follows (see also Appendix Figure 40):

1. With Abney level, determine the average percentage of slope by taking readings to the right and to the left of grade stake. (Example: right 38 percent, left 30 percent, average 34 percent.)

2. From Slope Stake Table under 1:1 slope (or whatever bank slope is desired) and opposite 34 percent, determine "S" (8.9 feet). Measure this distance from grade stake and at right angle to road and set slope stake.

3. From same table, find "C" or depth of vertical cut (2.9 feet) and mark this figure on slope stake.

4. Find distance "B" from table (5.6 feet), measure off horizontally from grade stake, and set rough stake at this point.

The Slope Stake Table is so constructed that reasonably close balance will be obtained between cut and fill if the indicated dimensions are followed during construction.

CONSTRUCTION

After the survey has been completed, it is important that the road be constructed properly. Building of logging roads usually does not require the services of a highway engineer, but certain basic construction principles must be followed.

Depending upon the skill and road building experience of the equipment operator, it may be necessary for a qualified person to provide some supervision during construction. Before the heavy equipment is engaged and put to work, the road location should be well marked and all preparatory work within the right-of-way should be completed. This will permit immediate and steady use of the machinery and will result in prompt completion at minimum equipment costs.

Clearing

Merchantable trees in the right-of-way are cut down and bucked into logs ahead of construction. Logs and tops should be moved far enough off the right-of-way that they will not interfere with construction. See Figure 4.

Figure 4. Right-of-way clearing is the first step in the construction of a woods road.

Figure 5. Brush and pole timber being cleared for roadway. (Courtesy John Deere Co.)

Figure 6. A typical woodlot road under construction. (Courtesy Caterpillar Tractor Co.)

Logging roads on small woodland properties are usually constructed by the logging contractor, sawmill operator, or by a contractor who rents out equipment or contracts jobs. These contractors often use whatever size equipment is most readily available, even though it is important economically that proper size equipment be used. A D-6 or D-7, or equivalent, is best suited for road jobs of 10 feet or 12 feet in width, with larger machines for wider roads. Machine rental rates normally include the services of an operator.

Stumps which will be covered by a foot or more of fill material should be cut low and need not be removed. All other stumps and roots over 3 inches in diameter should be dug out of the ground. This is usually accomplished by leaving a stump about 3 feet high to facilitate its removal with the bulldozer blade. If the right-of-way supports only brush or young timber, or where a sufficiently heavy tractor-dozer is engaged, no felling need be done and all material can be cleared by machine. See Figures 5 and 6.

Trees which are moved by bulldozer should not be left leaning or suspended above the ground. They present a hazard which should be eliminated at the time of construction. Snags which may fall into the road should also be felled. Blasting of rocks and boulders may be necessary on rare occasions, although this need can usually be avoided at the time of location. Even after construction is under way, it may be possible to by-pass such obstacles by minor changes in alignment.

If the road has a dead end, sufficient space should be cleared and leveled to provide for easy equipment turn-around.

Designs and standards

The designs and standards of a logging road are determined by certain basic economic considerations: the original construction costs and maintenance costs dictated by volume of traffic. Because the former is more immediately apparent, the latter is often neglected. Yet, just as the size of the load is determined by the size of the truck, so the total hauling expense is affected by the proportionate time the equipment spends on the logging road and by the ease with which the road is traversed. In other words, road designs and standards have a far greater affect upon the economics of a logging operation than is represented by original road construction costs. Excessive road maintenance and trucking expenses may more than offset savings in construction.

The desired width of single lane truck roads is from 10 to 12 feet, with greater widths at curves and turnouts. However, construction cost for a 12-foot road on a steep side slope may be as much as one-third higher than for a 10-foot road on the same location. The difference is represented by the high volume of earth to be moved out of the additional 2 feet.

Road banks may be cut just as steep as the stability of the material will permit. See Figure 7. Bank slopes may range from 1/2:1 on stable material to a 1:2 ratio in erosive soil. For details on designs and standards, refer to Appendix Figures 41 and 42.

Figure 7. Sloping road side bank. (Courtesy Caterpillar Tractor Co.)

Drainage and slope stabilization

It is difficult to over-emphasize the importance of adequate drainage in road construction. Provision must be made not only for passage of surface water from adjacent slopes, but also for rapid drainage of the road bed itself, which is necessary to keep the road in good, serviceable condition. Higher class roads generally are crowned to provide surface drainage.

Some cut and fill slopes require seeding and mulching. This is discussed in the section entitled "Skid Roads and Skid Trails."

Culverts

Probably the most common method of road drainage today is the installation of culverts. Culverts are made of steel, concrete, logs, and lumber. Weigle, in his publication, "Designing Coal-Haul Roads for Good Drainage," states:

> If possible, a culvert should be installed in the natural drainage channel and on the same grade as the stream. A culvert inlet should be placed on or below, but not above, the streambed. Avoid filling under a culvert to bring it up to grade. Seat the culvert on firm ground and compact the earth at least halfway up the side of the pipe to prevent water from leaking around it.
>
> Adequate cover is needed, the rule being a minimum of 1 foot or half the culvert diameter, whichever is greater. If adequate cover cannot be achieved, then a pipearch or two smaller culverts should be installed. The cover must also be compacted to prevent settling in the road. If erosion of the inlet end is a problem, a headwall must be provided. Sandbags, logs, concrete, or hand-placed riprap are suitable.

Figure 8 illustrates proper culvert installation as explained by Weigle.

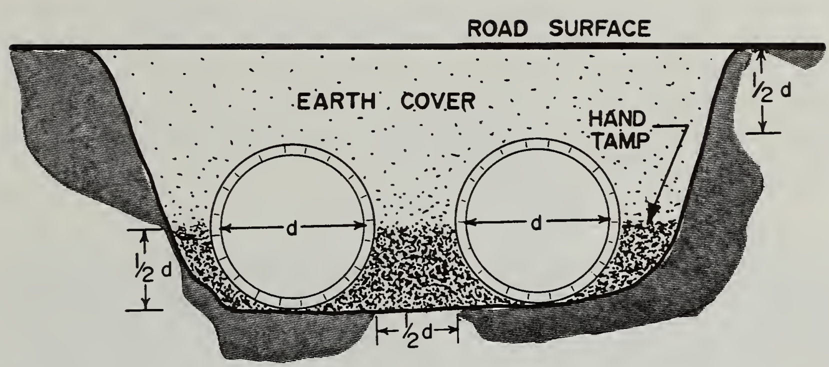


Figure 8. Culvert installation. Earth should be hand-tamped at least halfway up the side of the pipe. Space between pipes in a multiple culvert should be half the pipe diameter. Earth cover over pipes should also be half the culvert diameter in depth, but not less than one foot.

Normally, a culvert is placed on a 2 to 4 percent grade to prevent clogging. Flow velocity should be more than 2.5 feet per second to prevent sedimentation, but less than 8 feet per second to prevent scouring. Generally, a grade of 2 percent is sufficient to obtain velocity in this range. The outlet end of a culvert should be placed at or below the toe of the fill, and an apron of rock should be provided for the outflow to spill on. See Appendix Figure 43. A hasty method for estimating the cross-sectional area required for a culvert is shown in Appendix Figures 44 and 45.

Ditch relief culverts are used to move water under the road before the flow gains sufficient volume or head to erode the ditch. On an 8 to 10 percent grade, the culverts should be spaced 200 to 300 feet apart; on a 5 percent grade, about 500 feet apart is sufficient. These figures will vary locally, depending on type of soil, amount of rainfall, and width of road. Ditch relief culverts should cross the road at about a 30 degree angle (culvert outlet downgrade about half the road width) to provide better entrance conditions on steep grades. See Figure 9.

Figure 9. Ditch relief culvert. Culvert should cross road at about a 30-degree angle downgrade.

Structures for removing water from the road surface or diverting it across the road are the open-top culverts or dips. Open-top culverts are frequently used on woods roads. They are inexpensive to construct and quite serviceable when properly maintained. They can be constructed of poles or from sawn timbers. If made of durable wood or treated material, box culverts give many years of service. See Figures 10, 11, 12, and 13 and Table 2.

Figure 10. Open-top box culvert design and installation.

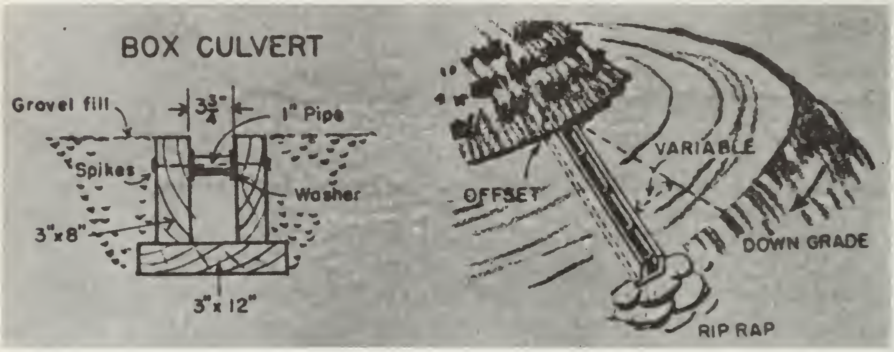


Figure 11. Open-top box culvert properly installed in road.

Figure 12. Open-top pole culvert design and installation.

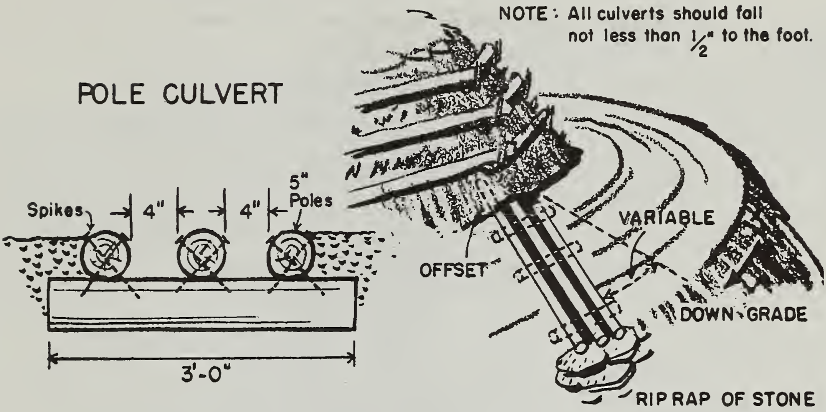


Figure 13. Open-top pole culvert installed in logging road.

Table 2

Suggested Distances between Open-top Culverts and Broad Based Dips

Road Grade	Spacing
Percent	*Feet*
2	300
4	200
6	167
10	140
20	120

NOTE: Actual distance between culverts will depend upon the nature of the road surface material and its tendency to erode.

"Thank-you-ma'ams" are frequently used on logging roads, especially where the volume of water is not expected to be great enough to wash them out. These, as well as culverts, should be placed across the road at an oblique angle in the direction of the waterflow, as illustrated in Figure 14. On mountain roads, this angle placement not only makes it possible for the culverts to clear themselves of dirt, stones, and debris, but also makes for safer truck travel in that two front wheels of a truck do not cross the drainage structure at the same time.

Outsloping the entire width of the road toward the fill bank provides good surface drainage and may reduce the number of culverts needed, and hence reduce the construction costs. The outslope should be only enough to divert the water, generally 1/4 inch to 3/8 inch to the foot. If the slope is apparent to the eye, it is usually too great. A road should not be outsloped in steep country or if it becomes slippery when wet or frozen. Truck travel becomes hazardous under such conditions.

Insloping the road toward the cut bank may be done to prevent erosion or as a safety precaution on slippery soils such as on curves. An insloped road requires the installation of culverts or stable dips unless the water will seep through pervious material.

A frequently used drainage structure on logging roads is the broad based dip. This is a carefully outsloped section of road which acts as a water catchment and drainage channel. It must be constructed accurately. Length and depth must be adequate to provide drainage, yet not excessive to endanger traffic at normal speeds. Dips should not be installed to handle live (constantly running) water. See Figure 15.

On occasion, it becomes necessary to prevent surface water from entering a stream—as on downgrade approaches to a bridge. This may be done by installing a culvert just ahead of the bridge and diverting the water into a sump hole or settling basin between road and stream. Such a catchment can usually be dug out with a bulldozer.

Figure 14. "Thank-you-ma'am" drainage structure.

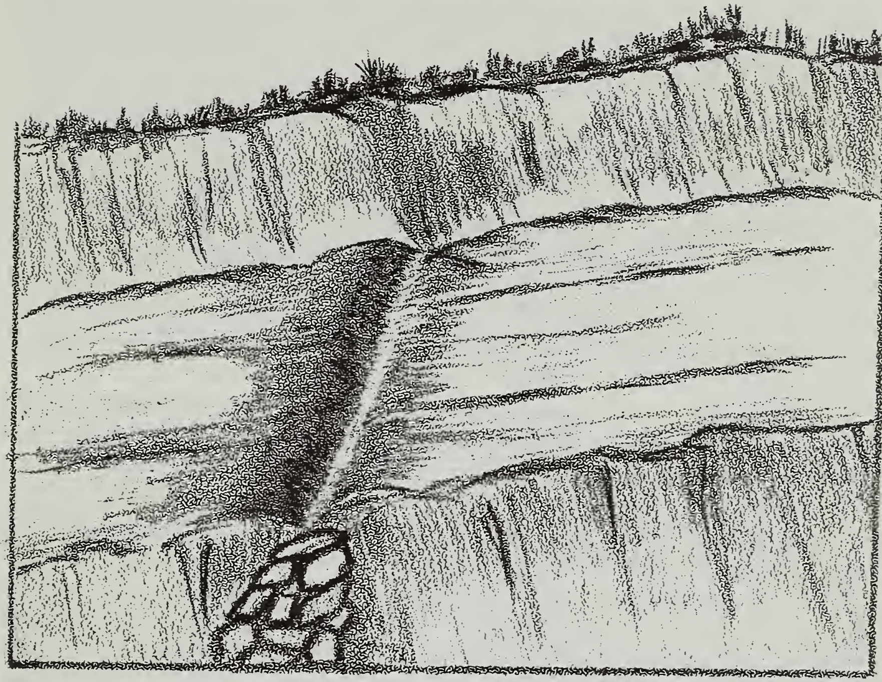
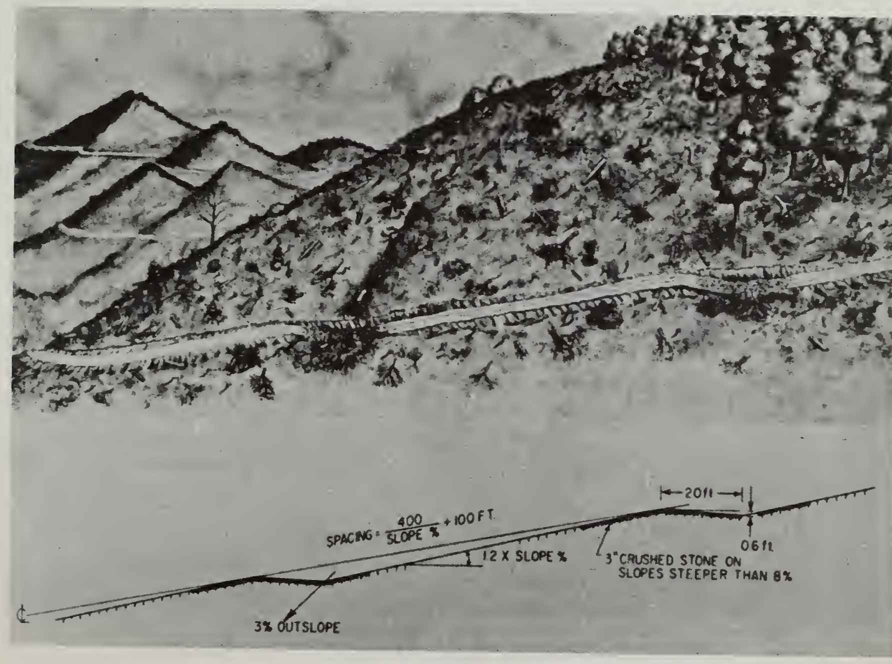


Figure 15. Broad based drainage dips can be used effectively on both truck roads and skid roads.



If long time use of the road is anticipated after completion of the immediate logging job, it is more economical to install drainage structures of corrugated metal or concrete pipe rather than to risk costly maintenance and early replacement of temporary culverts.

Bridges—General consideration

Careful consideration should be given to alternate road locations before deciding that a bridge is really necessary to transport timber out of a certain tract of woodland. It may be less expensive in the long run to move the timber in another direction over a longer route rather than to build a bridge. In any case, a bridge should not be constructed if a crossing can be made by less expensive means such as a culvert pipe or stable ford, unless water values rule out the latter.

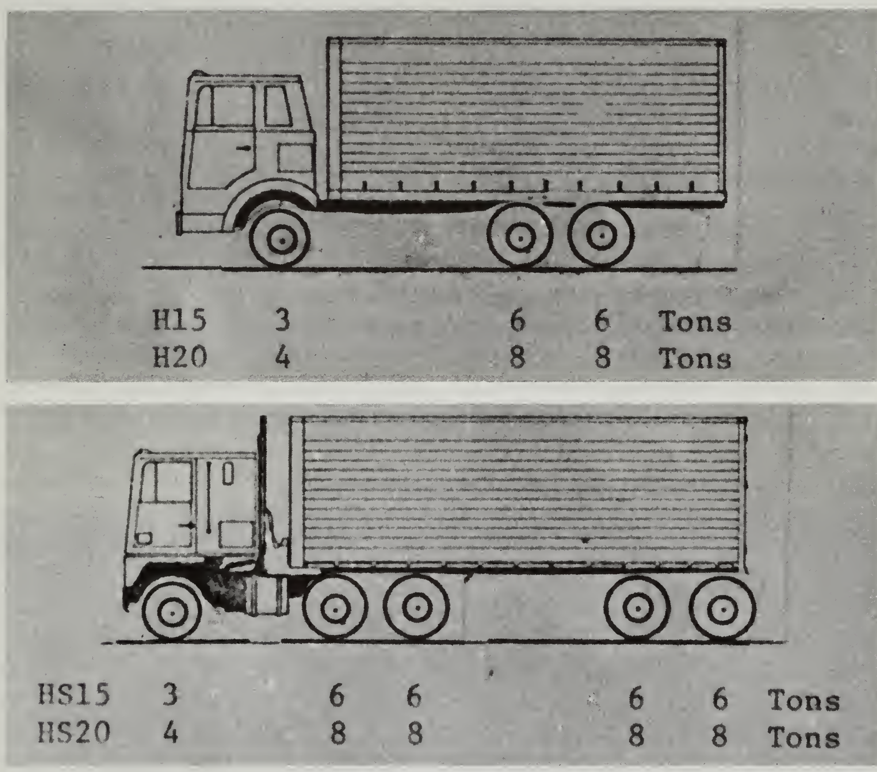
In selecting a site for a bridge, attention should be directed to the alignment of the stream as well as that of the road. The crossing should be at right angles, with alignment of stream and road straight in all four directions. The stream bed should be straight and should also be of uniform profile to provide for unobstructed flow of water. Approaches to a bridge should consist of the maximum practicable tangents, being not less than 50 feet in length on either side, if possible.

Piers and abutments should be in a direction parallel to the stream flow and must be imbedded in good foundation material. Skewed locations of bridge abutments and piers should be avoided whenever possible. The grade of the bridge should coincide with that of the road; i.e., if the bridge is to be built on a two percent grade, the approach should be the same grade for at least 50 feet at each end. Abrupt rises or falls in the grade line at the ends of the bridge are to be avoided. See Figures 16 and 17.

Figure 16. Approach to temporary bridge in logging road. Note uniform grade of approaches and bridge floor.

Figure 17. Side view of same bridge. Note bridge components—log abutments, stringers, sawn timber decking, run-planks, and wheel guards.

Figure 18. Example of tandem and semi-trailer truck gross weight distribution by axles.



The axle loadings, as shown in Figure 18, approximate standard bridge design loading. Maximum legal weight limits in most states approximate the H20 and HS20 loading. For detailed and accurate legal weight information, contact your State Department of Highways.

For bridge material and design, refer to the "Round Stringer Bridge Plan" in the Appendix, Figures 46 and 47. Native tree species are suitable for stringers in most bridges constructed on logging roads. Stringers should be large enough and sound to meet the load specifications provided in the plan.

The bridge floor consists of a 3-inch thick decking laid solidly across the stringers. Tops of the stringers should be slabbed off flat to provide a good bearing surface. The entire floor must be rigid enough to distribute the weight to all the stringers. Running planks, 3 inches thick, placed over the floor lengthwise and parallel to the stringers serve as wheel tracks.

Large, uniform-sized poles may be substituted for sawn bridge decking as floor material. Here, too, the poles are laid solidly across the stringers and fastened to them, and the running planks are installed on top of the pole decking. In either case, for safety, wheel guards of poles or sawn timbers should always be installed along the outer edges of the deck.

To shed water, strips of asphalt paper between the stringers and decking will prolong the life expectancy of the stringers.

For safe and specific information concerning bridge construction, contact an engineer familiar with this type of work.

Fords

Two words of caution about fords as stream crossings: (1) Avoid, if possible; and (2) Have stable stream beds and approaches. This stabilization can sometimes be achieved by a heavy application of large gravel or shale.

All crossings should be made at right angles to the stream and extra care taken to avoid any spillage of petroleum in or near the water.

MAINTENANCE

During the logging operation

Large trucks, such as those shown in Figures 19 and 20, are heavy and expensive; therefore, they require properly constructed and maintained roads to operate efficiently.

With properly located and well constructed roads, maintenance problems are relatively minor. This is especially true if good judgment is used in keeping off the road during the spring break-up and extended periods of poor weather.

Much of the road maintenance can be done by hand and may include opening drainage structures and ditches and their inlets, and removing slides, rocks, and material that has been sloughed off the banks. After early use of a newly constructed road, some sub-surface weaknesses, dips, or holes may appear which will require spot surfacing with some suitable material. See Appendix Figure 48.

Periodic grading of the road surface is necessary to fill in wheel ruts and to shape-up the road. See Figure 21. This can best be done by a motor or tractor drawn grader; however, such equipment may not be available. A bulldozer or rubber tired skidder may also be used. A common piece of equipment used for this purpose is a road drag, which is nothing more than a heavy platform built of timbers or iron members. It is usually weighted down heavily with stones and is pulled behind a truck or tractor, smoothing out the surface and filling in wheel ruts.

After logging

On logging roads that may not be used again for several years, certain steps should be taken to protect the road during a period of non-use.

Immediately after logging, the open-top culverts should be removed and replaced with water bars, dips, or ditches—their number and spacing depending upon the grade of the road. All of these structures should be of sufficient size to carry maximum runoff volumes to keep them from being washed out.

Natural revegatation of roads, ditches, and landings with grasses and weeds may prevent erosion. In easily eroded soil, all roads, banks, and landings should be

Figure 19. Tandem axle trucks of a 30,000 to 35,000 pound gross vehicle weight size are a common log hauling vehicle in the Northeast. They carry upward of 2,000 board feet of logs.

Figure 20. Tractor-trailers are used for long-log hauling. They haul 3,000-5,000 board feet of logs and require well constructed woods roads. (Courtesy International Harvester Co.)

Figure 21. A motor grader is an excellent piece of equipment for maintaining road surfaces. (Courtesy John Deere Co.)

quickly seeded to establish a protective vegetative cover. See Figures 22 and 23. A guide to remember for seeding purposes is: one mile of logging road 12 feet wide contains about one and one-half acres. Wherever possible, the road should be completely closed off to prevent use by unauthorized persons.

With the importance of a forest edge and openings in the woods to game birds and animals, seeding preference might be given to cover species that are recognized as beneficial to wildlife. Depending upon locality, climate, and site, these species

might include some of the following: lespedeza, fescue, blue grass, timothy, clover (white, red top, ladino, alsike), birdsfoot trefoil, oats, wheat, and rye.

If it is decided that the road will be kept open after logging is completed, then it would be advisable to follow these simple rules to protect the road: (a) Keep travel to a minimum. (b) Use only during dry weather. (c) Make periodic inspections and follow through with simple maintenance.

Figure 22. Log landing which was not seeded.

Figure 23. Similar log landing one and one-half years after seeding. The site is now well protected from erosion.

RIGHTS-OF-WAY

Where roads cross lands of other owners, permission to cross should be obtained. For permanent access roads, however, it is advisable to obtain written agreements. Written and recorded rights-of-way are of mutual benefit and provide protection of the interests of all parties.

A right-of-way agreement should define the road location, its points of ingress and egress, and width. All other pertinent information should be carefully noted. A simple survey may be desirable. Such conditions as the maintenance of fences, gates, cattle guards, and other improvements should be clearly specified. Monetary considerations or other forms of payment requested by the grantor should also be made a part of the agreement.

Should the road end on the right-of-way of a public secondary or primary highway, the local highway department office should be contacted. Many State highway departments have strict rules and regulations governing the entry of private roads onto public roads. Permits may be necessary.

It is suggested that before a right-of-way agreement is executed and recorded, a local attorney be consulted in order that the instrument conforms with whatever State requirements may be in force. A sample right-of-way agreement containing the important provisions is shown in the Appendix, Figure 49.

SKID ROADS AND SKID TRAILS

Skidding of logs is performed in the Northeast in a variety of ways depending upon locality and the economic circumstances of the operator. The most common method, however, is skidding of one or more logs by wheel or crawler-type tractor as shown in Figures 24 and 25.

Long-length skidding is becoming popular, especially so in connection with integrated sawlog and pulpwood operations. The recent development of fast and highly mobile articulated rubber tired skidders with such features as four-wheel drive and power steering is a notable improvement in logging equipment. These machines can operate successfully over steep terrain and on low-standard trails. They make long skids (a mile or more) economically feasible, which on some jobs reduces or eliminates the need for truck roads. See Figure 26.

Whatever method, or combination of methods, is contemplated in moving timber from stump to landing, each method requires its own particular type of skid trail or road. All of these, however, employ certain basic engineering principles in location and construction. Unfortunately, all too little attention has been paid in the past to the planning of an efficient skid road system in the woods. Improvements are considered to serve a very temporary purpose and little thought is given to what happens to the land upon the completion of the logging operation. Oftentimes, timber is skidded straight down the mountainside, no matter how steep, leaving in its wake eroding gullies and deposits of sediment at the foot of the slope and in the streams.

In managing timberlands, some thought must be given to planning for repeated operations on the same area, and provision must be made for the protection and re-use of the major improvements after a lapse of a cutting cycle. Also, whereas a

Figure 24. Farm tractors are commonly used on woodlots of gentle topography. Road requirements here are minimum.

Figure 25. Small crawler-type tractors are used for log and tree-length skidding. This piece of equipment is also used for road and trail construction. (Courtesy John Deere Co.)

Figure 26. Fast four-wheel power skidders such as this are well suited for tree-length skidding over long distances. They perform under many adverse conditions, but operate most efficiently on well located skid roads.

haphazardly built system of truck roads, skid roads, and trails may disturb as much as 20 percent of the surface, a well planned logging transport system need not occupy more than 10 percent of the land area. Here again, a map of the area or an aerial photo is extremely helpful. Tentative skid road locations can be plotted on paper before final location and construction begins.

The frequent objection to tree length logging, for reasons of damage to residual trees, can largely be overcome by the careful location of skid roads and directional felling. In such cases, alignment of the road becomes of major importance. Where wheeled arches and tractors with angle blades are used in skidding, special care

should be exercised in locating the road to prevent excessive damage to valuable residual trees.

The primary difference between a skid road and a skid trail lies in the degree of preparation prior to use. Main skid roads should be flagged, cleared, and graded. See Figure 27. Trails which are used to bring logs from stump to main skid road are usually not graded and need only a minimum amount of clearing, as shown in Figure 28. Where skidding is contemplated by tractor equipped with a winch, logs are moved directly from stump to skid road without prepared spur trails.

Figure 27. Typical skid road which has been cleared and graded. (Courtesy Caterpillar Tractor Co.)

Figure 28. Skid trails often require little preparation. (Courtesy International Harvester Co.)

Landing and Skid road location

With special attention to proper drainage and soil stabilization, the following points should receive consideration in developing a landing location and road system:

1. Locate landings first. Road approach should have a low grade. The timber length—whether short log or tree length—the loading method, and type of hauling equipment used will dictate landing requirements. See Figure 29.

2. Keep skid road grades as low as topography will permit. Do not go straight up the slope, but proceed slanting up the hill.

3. Avoid stream beds, rocky places, and adverse grades.

4. Cross stream courses at right angles.

5. Break the grade occasionally to avoid long, straight grades which permit water to build up and cause erosion.

6. Wherever possible, build the skid roads from the top down—it is much easier.

Figure 29. Suitable landing site located on main haul road. Wheel loader loading trailer with logs. (Courtesy Caterpillar Tractor Co.)

Figure 30. Skid road needing water turnouts. Heavy rains will start soil eroding here.

7. Water turnouts should be installed on main skid roads at intervals not greater than is indicated in Table 2, which governs spacing of culverts on truck roads. See Figure 30. It is also important to provide a cross-drain immediately above extra steep pitches in the road and below bank seepage spots. See Figure 31.

8. Construct small bridges or install culverts at live stream crossings, particularly on the main skid roads and especially where water values are highly important.

9. Install fender logs on the outside edge of skid roads on steep slopes, and also at turns and switchbacks, to prevent logs from rolling off the skid road and to protect adjacent standing timber from damage.

Maintenance of skid roads during periods of use is usually confined to keeping the surface water drained off. However, immediately upon seasonal shut-down, or at completion of the operation, certain steps may be taken to protect the road against erosion:

1. Water bars should be installed at recommended intervals to provide for proper drainage. See Table 3.

2. Rocks, brush, and logging debris can often be used as water retardants on side trails. See Appendix Figure 50.

3. Where skid roads cross streams or intermittent water courses, the stream beds should be cleaned of slash and restored to natural shape and grade.

Figure 31. Profile of skid road showing water bars.

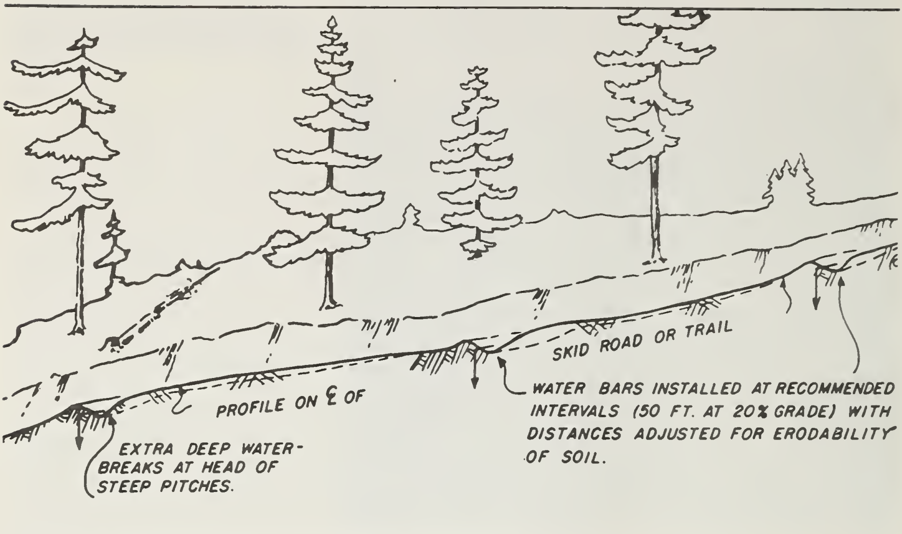


Table 3

Recommended Distances between Water Bars on Skid Roads and Truck Roads Which Have Been "Put to Sleep"*

Grade of Road	Distance between Water Bars
Percent	*Feet*
2	250
5	135
10	80
15	60
20	45
25	40
30	35
40	30

*With the skid roads protected and "put to sleep" little attention will need to be given them during the ensuing years. And, when the time comes to remove another crop of timber from the area, the protected logging road will result in lower operating costs and correspondingly higher timber prices to the land owner.

4. Landings and trail sections of extreme grade should be seeded with grass or legumes to provide early permanent vegetative cover.

5. Areas sensitive to erosion, aesthetics, and drought conditions may require a mulch. Some effective mulches are straw, bark, and wood chips. Contact your local service forester, Soil Conservation Service representative, or county agent for proper seeding and fertilizing information.

IN SUMMARY – IMPORTANT RULES FOR PLANNING, CONSTRUCTING, AND MAINTAINING LOGGING ROADS

Locating the road

1. Remember, appearance is important, too.
2. Keep road grade low.
3. Side-hill locations are generally best.
4. Keep roads far enough away from streams.
5. Avoid obstacles and stream crossing, if possible.
6. Preplanning saves time and construction costs.

Construction

1. Good road design gives lowest total construction and hauling costs.
2. Build the narrowest road that will do the job safely.
3. Proper drainage pays.

Maintenance

1. Keep off roads during wet season.
2. After logging, remove temporary drainage structures.
3. Install water bars.
4. Seed, fertilize, and mulch as necessary.

Rights-of-way

1. Get written permission to cross lands of others.
2. Secure any necessary permit for public road access.

Skid roads and skid trails

1. Locate landings first.
2. Planning is also needed for an efficient skid road operation in the woods.
3. Minimize the amount of area needed for skid roads and skid trails.
4. Avoid residual tree damage when skidding.
5. Install water turnouts as needed.

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APPENDIX

The Williams-Steiger Occupational Safety and Health Act of 1970

Public Law 91-596 was passed by the 91st Congress of the United States and signed into law by President Nixon on December 29, 1970. This law is known as "The Williams-Steiger Occupational Safety and Health Act of 1970 (OSHA)". It became effective on April 27, 1971. The purpose of the law is "to assure so far as possible every working man and woman in the nation safe and healthful working conditions and to preserve our human resources." Statistics show that the accident rate in logging is very high; therefore, the Secretary of the U. S. Department of Labor has chosen logging and several other high accident rate industries as "target industries". This means that an all out effort by State and Federal Governments will be made to reduce injuries and deaths in these hazardous occupations.

Figure 32. Rules and regulations covering logging roads and trails as contained in the Williams-Steiger Occupational Safety and Health Act of 1970.

Logging Roads and Trails are Included in the Act*

Rules and regulations covering logging roads and trails are listed in Subpart R, Section 1910.226. They read as follows:

(15) *Roads and trails, general.* (i) Roads shall be maintained and hazardous conditions corrected.

- (ii) Where vision is limited, warnings shall be posted.
- (iii) Curve radii shall be the maximum consistent with terrain.
- (iv) When nightwork is necessary adequate lighting shall be provided.
- (v) Local road standards and maximum weight of traffic expected shall be used as guides for materials, construction features, and drainage.

(16) *Road and trail pioneering and earthwork.* (i) Banks at the borrow area shall be sloped to prevent slides.

- (ii) Backfill shall be adequately compacted.
- (iii) Roadside banks shall be sloped or stabilized to prevent slides.
- (iv) Overhanging banks, large rocks, and debris shall be removed or secured.
- (v) Where riprap is used, the material and design shall assure safe containment of material.
- (vi) Trees or snags which may fall into the road shall be felled.

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*A copy of the "Federal Register", Occupational Safety and Health Standards, Volume 37, Number 202, Part II, may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, Price: 20¢

(17) *Road and trail drainage.* (i) Drainage shall be provided to prevent wash-outs and landslides.

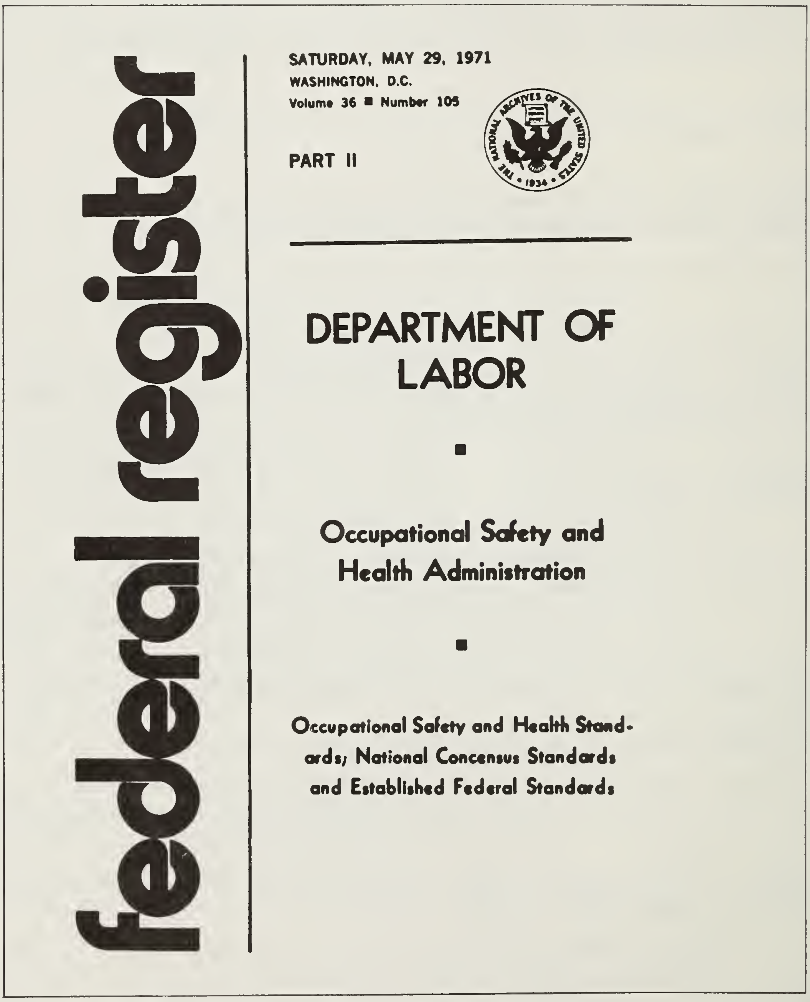
(ii) Culverts shall be of adequate strength and of a size to handle maximum runoff.

(iii) Where necessary, ditches and banks shall be stabilized by vegetation, riprap, or other adequate means.

(18) *Road and trail surfacing.* Road surface shall be properly compacted, graded, and crowned.

(19) *Bridges.* (i) Construction shall provide for maximum anticipated loads and side thrust with a substantial safety factor.

(ii) Bridges shall be decked and curbed.



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PART II

DEPARTMENT OF LABOR

■

Occupational Safety and Health Administration

■

Occupational Safety and Health Standards; National Concensus Standards and Established Federal Standards

Figure 33. This Federal Safety Standard contains 248 pages, and it covers several industries. Rules and regulations covering logging roads and trails are included.

Figure 34. Typical road cross-sections on side slopes of varying degrees.

Figure 35. Slope and bank chart.

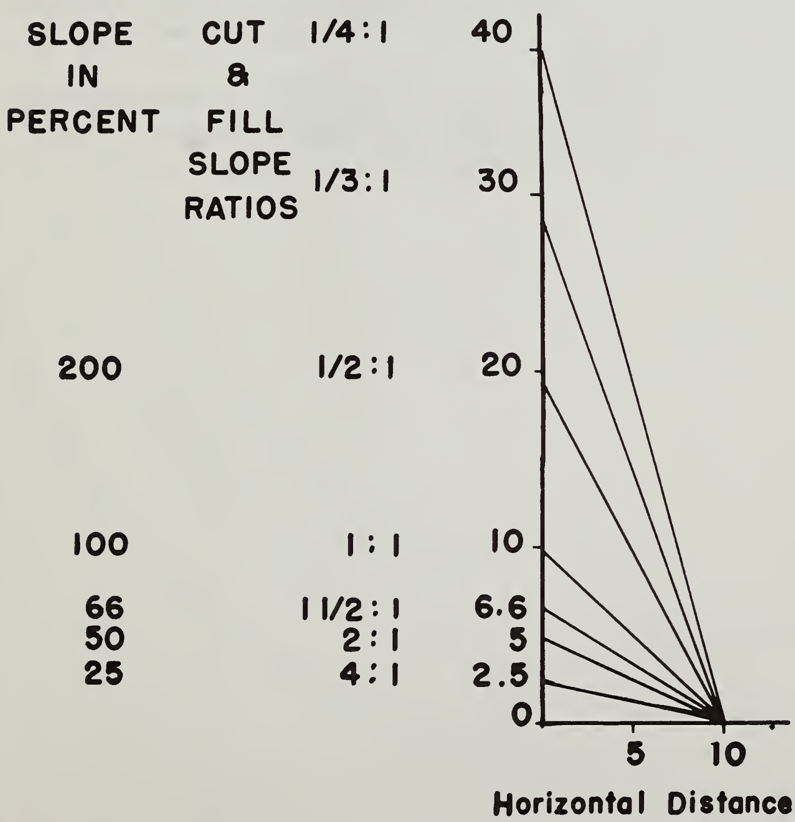


Figure 36. Method for sizing up road use on a planned logging job in terms of number of loads that will be hauled over the road.

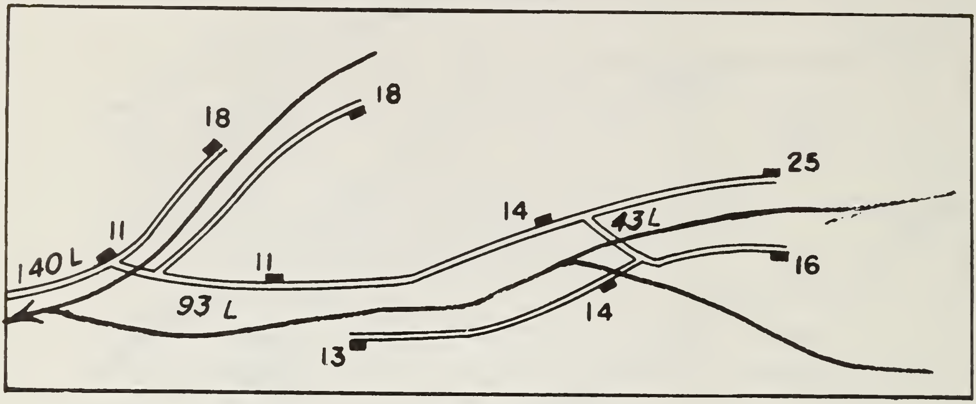


Illustration is based on a 100-acre tract with an average cut of 2.5 MBF per acre and trucks that will haul an average load of 1.8 MBF. Figures at landings represent the number of loads to be picked up at each point, and (L) figures represent total number of loads that will be hauled over the road past this point.

Loads at landings are computed from estimate of timber that will be skidded to each landing. Where timber is uniformly distributed, this can be determined from the area served by each landing.

Expressing the proposed use of a logging road in terms of number of loads that will be hauled over it can serve as a guide to the design and standards to which the various sections and spurs need to be constructed.

Figure 37. Suggested method for laying out a curve.

1. Set a stake at beginning of curvature (end of straightaway)—point A.
2. Decide spacing of stakes in curve (distances from 25 to 100 feet are suitable for logging roads, with the closer spacing applicable to sharp curves).
3. Measure selected distance from A to C, in line with B.
4. At right angles to CA, set stake at D and mark distance CD on measuring stick.
5. Lay off same distance from D to E, and distance AC from A to E. Set temporary stake at E.
6. Double selected distance to F in line with AE and set stake at F.
7. Pull up temporary stake at E and set it at G by using measuring stick and tape in same way as at E.
8. Set stake H in same manner as that by which F was located.

This procedure is repeated around the curve. As long as all measurements are the same each time, the curve will be smooth. If it does not end at the right place for the next straightaway, either increase or decrease length marked on measuring stick and reset the stakes.

By using 25-foot distance A-C, a 2-foot measuring stick C-D will produce a curve with a radius of approximately 157 feet;

3-foot stick produces radius of 106 feet,
4-foot stick produces radius of 80 feet,
5-foot stick produces radius of 65 feet, and
6-foot stick produces radius of 55 feet.

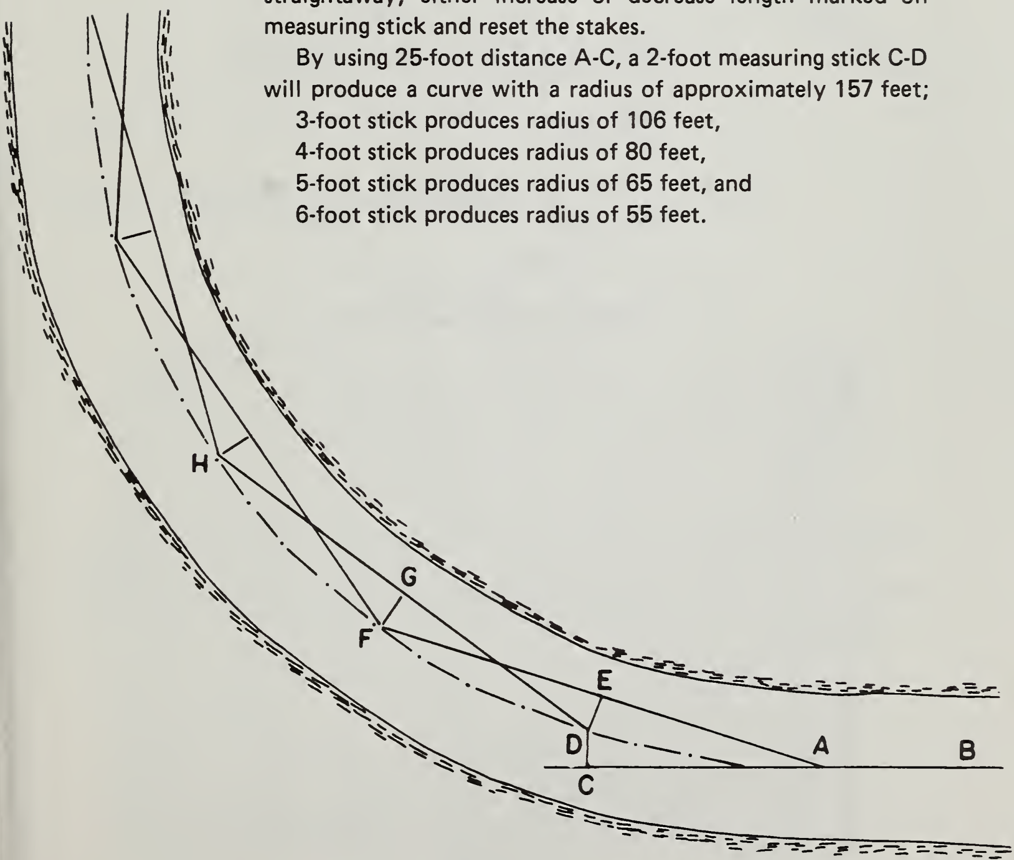


Figure 38. Turnout plan.

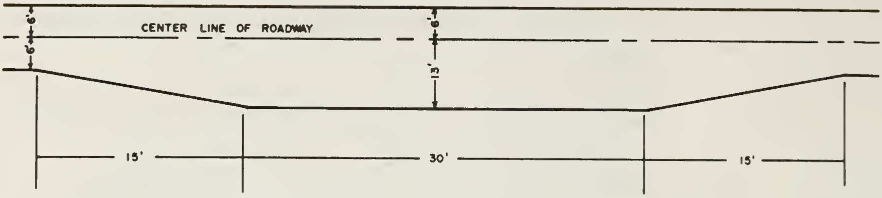
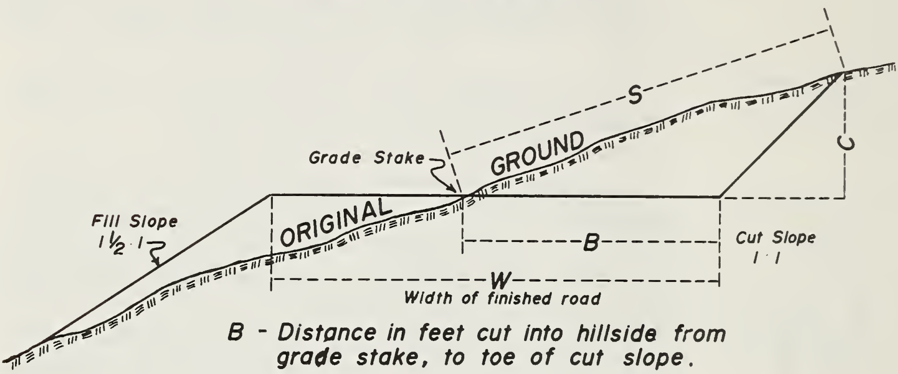


Figure 39. Slope stake sketch.



B - Distance in feet cut into hillside from grade stake, to toe of cut slope.

C - Vertical cut in feet, to be marked on cut stake.

S - Distance along slope to be measured from grade stake to cut stake.

Figure 40. Slope stake table.

Slope %	1 : 1 Slope			¾ : 1 Slope			½ : 1 Slope			¼ : 1 Slope		
	B	C	S	B	C	S	B	C	S	B	C	S
10	5.3	0.6	5.9	5.4	0.6	5.9	5.5	0.6	5.8	5.3	0.5	5.5
12	5.3	0.7	6.1	5.4	0.7	6.0	5.5	0.7	5.9	5.3	0.7	5.5
14	5.3	0.9	6.3	5.4	0.9	6.1	5.5	0.8	6.0	5.4	0.8	5.6
16	5.4	1.0	6.4	5.5	1.0	6.3	5.6	1.0	6.1	5.4	0.9	5.7
18	5.4	1.2	6.6	5.5	1.2	6.4	5.6	1.1	6.3	5.5	1.0	5.8
20	5.4	1.4	6.9	5.5	1.3	6.6	5.6	1.3	6.4	5.5	1.2	5.9
22	5.4	1.5	7.2	5.5	1.5	6.8	5.6	1.4	6.5	5.5	1.3	6.0
24	5.4	1.7	7.4	5.6	1.6	7.0	5.7	1.6	6.7	5.6	1.4	6.1
26	5.5	1.9	7.6	5.6	1.8	7.2	5.7	1.7	6.8	5.6	1.6	6.3
28	5.5	2.1	7.9	5.7	2.0	7.4	5.8	1.9	7.0	5.7	1.7	6.4
30	5.5	2.4	8.2	5.7	2.2	7.7	5.8	2.0	7.2	5.8	1.9	6.5
32	5.5	2.6	8.6	5.7	2.4	7.9	5.8	2.2	7.3	5.8	2.0	6.7
34	5.6	2.9	8.9	5.8	2.6	8.2	5.9	2.4	7.5	5.9	2.2	6.8
36	5.6	3.2	9.3	5.8	2.9	8.4	6.0	2.6	7.7	5.9	2.4	7.0
38	5.7	3.4	9.7	5.9	3.1	8.7	6.0	2.8	8.0	6.0	2.5	7.1
40	5.7	3.8	10.2	5.9	3.4	9.1	6.1	3.0	8.2	6.1	2.7	7.3
42	5.8	4.2	10.7	6.0	3.7	9.5	6.2	3.3	8.5	6.2	2.9	7.5
44	5.9	4.6	11.4	6.1	4.0	9.9	6.3	3.5	8.8	6.3	3.1	7.7
46	6.0	5.0	12.1	6.3	4.4	10.4	6.4	3.8	9.1	6.4	3.3	7.9
48	6.0	5.6	12.8	6.4	4.8	10.9	6.5	4.1	9.4	6.5	3.5	8.2
50	6.1	6.1	13.6	6.5	5.2	11.6	6.6	4.4	9.8	6.6	3.8	8.5
52	6.2	6.8	14.6	6.6	5.6	12.2	6.7	4.7	10.2	6.7	4.0	8.7
54	6.4	7.4	15.7	6.8	6.1	12.8	6.9	5.1	10.7	6.9	4.3	9.1
56	6.5	8.3	16.9	7.0	6.7	13.6	7.1	5.5	11.2	7.1	4.6	9.4
58	6.7	9.2	18.4	7.1	7.2	14.4	7.3	5.9	11.8	7.3	4.9	9.8
60	6.9	10.4	20.1	7.3	7.9	15.5	7.5	6.4	12.5	7.5	5.3	10.3
62	7.4	11.9	22.5	7.7	8.8	16.7	7.9	7.1	13.4	7.9	5.8	10.9
64	7.9	13.8	25.7	8.2	9.9	18.3	8.4	7.7	14.4	8.4	6.3	11.6
66	8.5	16.4	30.1	8.7	11.4	20.6	8.9	8.8	16.0	8.9	7.0	12.8

Figure 41. Typical clearing section.

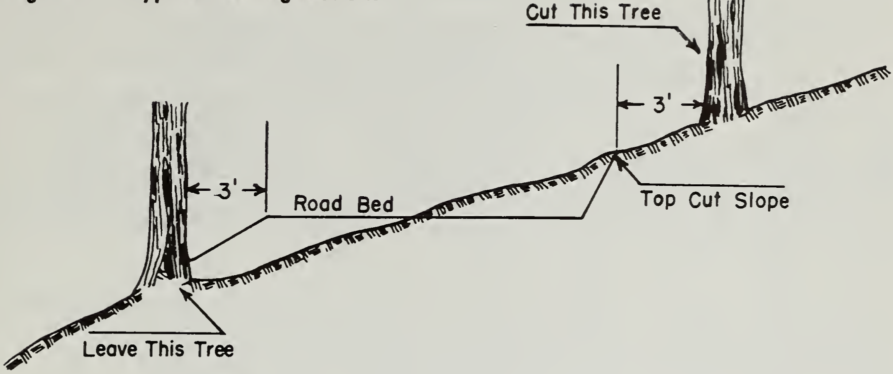


Figure 42. Typical grading section.

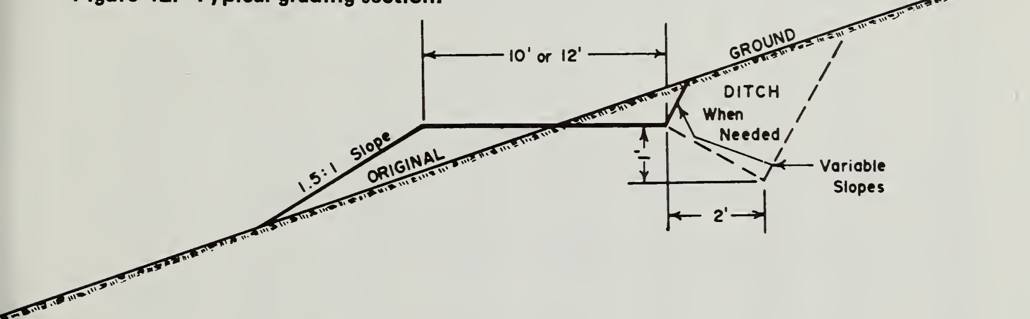
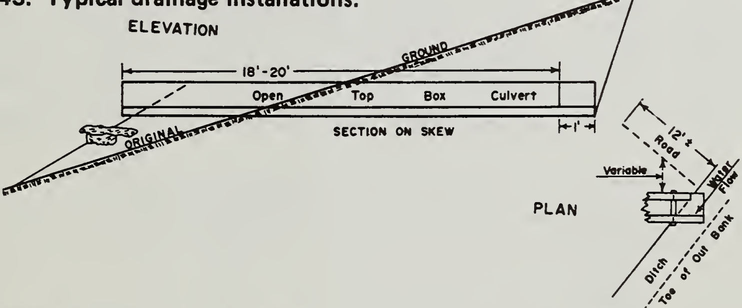


Figure 43. Typical drainage installations.



Recommended minimum slope of culverts is 2% to 4% where topography permits.
It is desirable that the outlet be placed on undisturbed soil in order to reduce erosion.

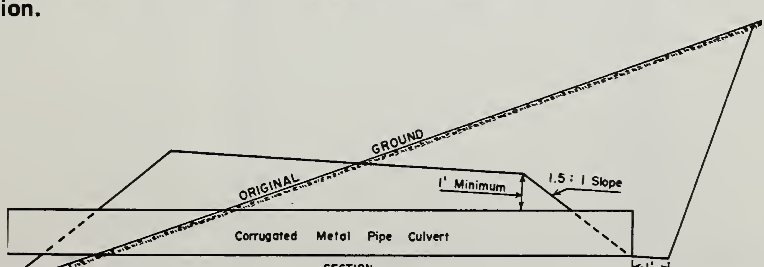


Figure 44. Drainage table.

Based on Talbot's Formula for a 2½" Per Hour Rainfall

No. of Acres	AREA IN SQUARE FEET REQUIRED FOR WATER WAY							
	Impervious 100% Runoff	Steep Slopes Heavy Soils Moderate Cover		Moderate Slopes Heavy to Light Soils Dense Cover		Gentle Slopes Agricultural Soils & Cover		Flatland Pervious Soils
	C = 1.00	C = .80	C = .70	C = .60	C = .50	C = .40	C = .30	C = .20
2	1.0	0.8	0.7	0.6				
4	1.7	1.4	1.2	1.0				
6	2.3	1.9	1.6	1.4	1.2	0.9	0.6	
8	2.9	2.3	2.0	1.7	1.4	1.2	0.9	0.6
10	3.4	2.7	2.4	2.0	1.7	1.4	1.0	0.7
20	5.8	4.6	4.0	3.5	2.9	2.3	1.7	1.2
30	8.0	6.3	5.4	4.8	4.0	3.2	2.4	1.6
40	9.8	7.8	6.8	5.9	4.9	3.9	3.0	2.0
50	11.6	9.3	8.0	7.0	5.8	4.6	3.5	2.3
60	13.4	10.7	9.2	8.0	6.7	5.3	4.0	2.7
70	15.0	12.0	10.3	9.0	7.5	6.0	4.5	3.0
80	16.6	13.3	11.5	10.0	8.3	6.6	5.0	3.3
90	18.2	14.6	12.5	11.0	9.1	7.2	5.4	3.6
100	19.7	15.8	13.5	11.8	9.8	7.8	5.8	3.9
150	26.9	21.2	18.5	16.0	13.3	10.7	8.0	5.4
200	33.2	26.8	22.9	20.0	16.7	13.3	10.0	6.6
250	39.5	31.5	27.1	23.8	19.7	15.7	11.8	7.9
300	45.7	36.1	31.0	27.1	27.0	18.0	13.5	9.0
350	51.0	40.6	35.0	30.5	25.3	20.2	15.0	10.1
400	56.0	45.0	39.0	33.9	28.0	22.2	16.7	11.2
450	61.7	49.7	42.0	37.0	30.6	24.2	18.0	12.3
500	66.8	52.8	46.0	40.0	33.2	26.5	19.8	13.2
600	77.0	61.6	52.5	46.0	38.2	30.3	22.8	15.3
700	86.0	68.4	59.5	52.0	43.0	34.0	25.8	17.2
800	96.0	76.1	65.8	57.0	47.5	38.0	28.5	19.0
900	104.0	83.0	71.7	62.2	51.9	41.5	31.1	20.8
1000	113.0	90.0	77.7	68.0	56.5	45.0	33.7	22.4

Figure 45. Sizes of round pipe needed for areas of waterway listed in drainage table.

Area	Diameter
Square Feet	*Inches*
1.25	15
1.80	18
3.10	24
4.90	30
7.10	36
9.60	42
12.60	48
15.90	54
19.60	60
23.80	66
28.30	72
33.20	78
38.50	84
44.20	90

EXPLANATIONS ON THE USE OF DRAINAGE TABLE

The drainage table as shown in figure 44 may be used in determining the size of drainage structures required to drain an area under run-off conditions resulting from a maximum rainfall of 2½ inches per hour.

It is based on Talbot's Formula: $A = C\ \sqrt[4]{M^3}$

However, Talbot's Formula as shown is used for a maximum of 4 inches of rainfall per hour. The drainage table for 2½ inches per hour rainfall as shown was developed by taking 62½% $\left(\frac{2.5}{4.0}\right)$ of the above formula.

Where: M = Acres of drainage basin

C = Constant factor based on a combination of soil absorptive capacity, slope and cover (.70 factor is adequate for most conditions, prevailing in the Northeast. 1.00 represents complete run-off of precipitation).

A = Cross-sectional area of waterway required to carry run-off by bridge or culvert.

How to use table:

Example No. 1 — Area to be drained, 70 acres.

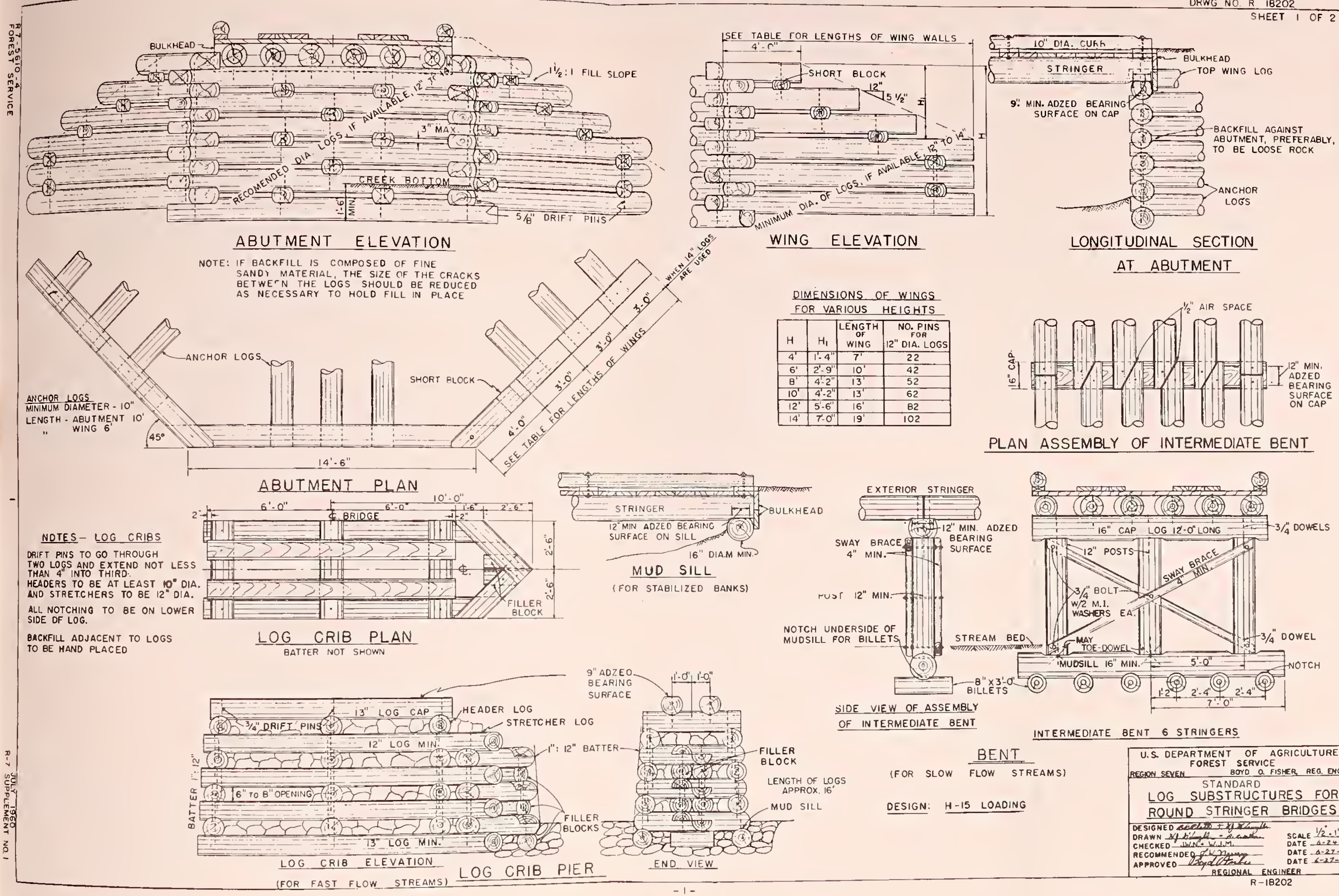
Under C, opposite 70, find area required — 10.3 square feet. Under the area table for round pipe (figure 45), this falls between a 42-inch and a 48-inch pipe. Use 42-inch with an area of 9.6 square feet.

If a wood or other type box culvert is planned, one 3 feet x 3.5 feet would furnish the required area.

Example No. 2 — Area to be drained, 450 acres.

Area of waterway required: 42 square feet. This requires a 90-inch round pipe or a bridge of such dimensions that will furnish the required area; namely: 5 feet x 8 feet, or 4 feet x 11 feet, or 3 feet x 15 feet, etc.

Figure 46. Log substructures for round stringer bridges.



DIMENSIONS OF WINGS FOR VARIOUS HEIGHTS

H	H₁	LENGTH OF WING	NO. PINS FOR 12" DIA. LOGS
4'	1'-4"	7'	22
6'	2'-9"	10'	42
8'	4'-2"	13'	52
10'	4'-2"	13'	62
12'	5'-6"	16'	82
14'	7'-0"	19'	102

Figure 48. Aggregate (in cubic yards) required for one mile of road.

Width of Road Ft.	Sq. Yds. per lineal Foot	Sq. Yds. per Mile	Depth in Inches (Loose)					
			1	2	3	4	5	6
10	1.11	5867	163.0	326.0	489.0	652.0	815.0	978.0
12	1.33	7040	195.6	391.2	586.8	782.4	978.0	1173.6
14	1.55	8213	228.2	456.4	684.6	912.8	1141.0	1369.2
16	1.77	9387	260.8	521.6	782.4	1043.2	1304.0	1564.8
18	2.00	10560	293.4	586.8	880.2	1173.6	1467.0	1760.4
20	2.22	11733	326.0	652.0	978.0	1304.0	1630.0	1956.0

NOTE: 16.30 cubic yards equals one-inch deep, one-foot wide, and one-mile long. When aggregate is compacted, increase above figures 15-30% depending on type and gradation of material.

Figure 49. An example of a right-of-way agreement.

RIGHT-OF-WAY AGREEMENT

THIS INDENTURE, MADE THIS __________ Day of ______________ , 19___
Between ____
____
____
of the County of ____________________________ , State of ________________,
grantor, party of the first part, and ____________________________________
____
____
of the County of ____________________________ , State of ________________,
party of the second part, WITNESSETH: ____________________________________
____
that for and in consideration of ____
____
receipt of which is hereby acknowledged; the party of the first part does hereby grant, bargain, sell, and convey unto the party of the second part and its assigns as easement and right-of-way for road purposes for a road to be located, constructed, operated, and maintained across the grantor's premises located in the County of ____________________________ , State of ________________ , the said right-of-way to be in conformity with and located upon the ground according to a mutually agreed upon location which is described as follows: ____________
____
____
____

1. PROVIDED: However, that if at any time this easement or any road constructed thereon shall be abandoned by the party of the second part, or its assigns, the rights and privileges hereby granted shall cease and terminate and the premises traversed thereby shall be freed from said easement fully and completely as if this agreement had not been made.

2. PROVIDED: However, that this easement shall become null and void and shall not extend beyond ____ .

3. PROVIDED: Also, that in the event of termination of this easement upon the satisfactory completion of the current period of use and enjoyment of its privileges by the party of the second part, another need arises for this right-of-way in the future, the party of the first part will consider favorably such a request by the party of the second part, its successors or assigns.

4. PROVIDED: That the party of the second part maintains and repairs fences, gates, and other improvements which have been damaged and broken as a result of the enjoyment of the easement and which are on the lands of the party of the first part and to the satisfaction of the party of the first part.

5. PROVIDED: That the party of the second part will not assign his rights or responsibilities under this agreement in whole or in part without the written consent of the party of the first part.

IN WITNESS WHEREOF: the said grantor and the said grantee have hereunto subscribed their names and affixed their seals the day and year herein above written.

Witness:

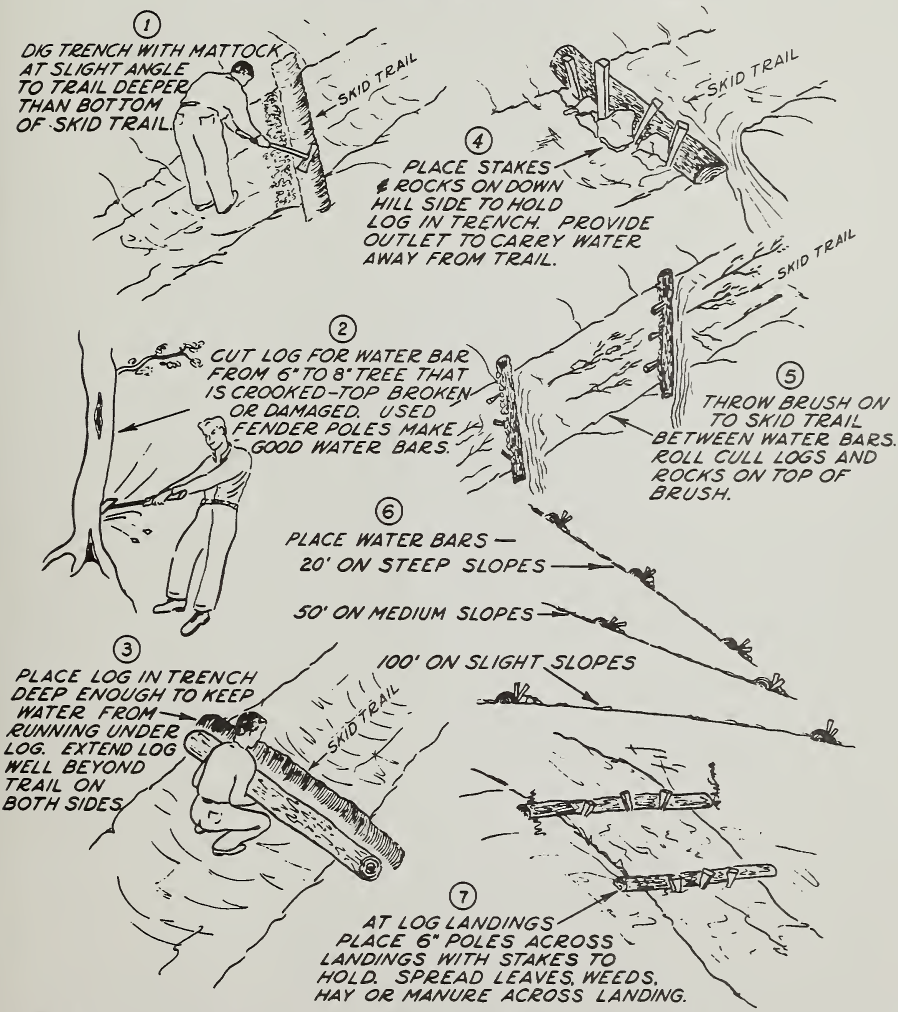
____________________ ____________________

____________________ ____________________

____________________ ____________________

____________________ ____________________

Figure 50. Skid trail erosion control devices.



The erosion control practice shown here requires a considerable amount of hand labor. The more common practice is to install these devices with tractors using the bulldozer blade.